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⑤④ Load indicating washer and fastener assembly including such load indicating washer.

⑤⑦ A non-heat treated load indicating washer (10) for visually indicating the magnitude of compressive force applied by a fastener (34, 36, 46) to opposed surfaces of the washer and a fastener assembly including such load indicating washer. The washer has a number of integral protuberances (14) struck from the washer and spaced from the inner (16) and outer (18) peripheries of the washer, each protuberance has a truncated concave basal surface (24) lying within the confines of the washer and a raised convex surface (32). The number and size of the protuberances (14) depend on the compressive force such that the protuberances will deform into the washer when the compressive force reaches a predetermined magnitude.

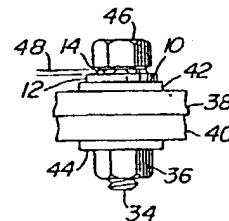


FIG. 5

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Load indicating washer and fastener assembly
including such load indicating washer

5 This invention relates to a load indicator washer and a fastener assembly, and, more particularly, to a load indicator washer for use with a bolt which washer provides means to determine the tension in the bolt during tightening of the bolt in a fastener assembly.

10 U.S. Patent No. 3,187,621 to Turner (1965) discloses a load indicator washer having a number of protuberances struck from the body of the washer. The protuberances have a concave basal surface lying within the confines of the body and a complementary convex
15 surface which extends out of the plane of the body of the washer. When a compressive force is applied to the opposed surfaces of the washer by a fastener, such as a bolt, the protuberances or portions raised from the body of the washer deformed into the body of the washer. The
20 distance that the raised portions extend out of the body is an indication of the tension in the bolt. The washer of this patent performed reasonably well. However, the washer had to be heat treated prior to use.

25 It is an object of this invention to provide an economical load indicating washer which more uniformly and consistently indicates a given load.

30 It is also an object of this invention to provide a load indicating washer which does not have to be heat treated prior to use.

It is a further object of this invention to provide a load indicating washer which does not have to be heat
35 treated after it is made and thus can be tested for load

indication at the machine which makes the washer.
After such testing, if necessary, the machine can be
adjusted to provide a proper load indicator washer.

- 5 The above objects can be accomplished by a load
indicating washer for visually indicating the magnitude
of a compressive force applied by a fastener to opposed
surfaces of the washer. The washer has a body portion,
a plurality of protuberances struck from the body
10 portion at spaced intervals and integrally formed with
the material of the body portion. The protuberances
are spaced from the inner and outer peripheries of the
body with each protuberance being oblong in outline
and defined by substantially parallel side surfaces.
- 15 Each protuberance has a truncated concave basal surface
lying within the confines of the body portion, i.e.
the truncated concave basal surface has arcuate end
surfaces and a flat center surface, and a convex
surface which is a raised portion extending out of the
20 plane of the body portion. The number and size of the
protuberances depend on the compressive force intended
to be applied to the washer. In addition, the number
and size of the protuberances are such that the raised
portions plastically deform into the body portion when
25 the compressive force reaches a predetermined magnitude.

FIGURE 1 is a plan view of the washer.

FIGURE 2 is an end view of FIGURE 1.

5 FIGURE 3 is a view taken along the lines 3-3 of
FIGURE 1.

10 FIGURE 4 is a view taken along the lines 4-4 of
FIGURE 1.

FIGURE 5 is an elevational view of a fastener
assembly of this invention prior to tightening the
assembly.

15 FIGURE 6 is a view similar to FIGURE 5 except that
the fastener assembly has been tightened.

Referring to FIGURES 1 and 2 a load indicating
washer 10 has an annular body portion 12 and a plurali-
20 ty of protuberances 14 struck from the material of the
washer 10, i.e. the protuberances 14 are an integral
part of the washer 10. The washer 10 has an inner peri-
phery 16 and an outer periphery 18. The inner peri-
phery 16 outlines the hole 20 of washer 10. The protu-
25 berances 14 extend tangentially to a circle concentric
with the inner periphery 16 and are spaced from inner
periphery 16 and outer periphery 18. The protuberances
14 in the plan view of FIGURE 1 are oblong in shape and
are located at spaced intervals about the body portion
30 12. The sides 22 of each protuberance 14 are substantial-
ly parallel to each other.

Referring to FIGURES 3 and 4, each protuberance 14
is struck from the material of the washer 10 and in-
35 cludes a basal truncated concave surface 24. By basal
truncated concave surface 24 is meant the surface formed

by arcuate end surfaces 26 and the flat or straight center surface 28. Extending above the plane of the body portion 12 of the washer 10 is a raised portion 30. As shown in FIGURE 4, the raised portion has straight 5 parallel side surfaces 22 and a top convex surface 32.

Referring to FIGURES 5 and 6, a fastener assembly includes a bolt 34 and a nut 36 in threaded engagement for clamping together members 38, 40. Bolt 34 passes 10 through holes in load indicator washer 10, hardened steel flat washer 42, members 38, 40 and standard washer 44. Load indicator washer 10 is positioned such that the protuberances 14 engage the underside of the head 46 of bolt 34. Positioned between the load indi- 15 cator washer 10 and the outer surface of member 38 is a hardened steel washer 42. Positioned between the outer surface of member 40 and nut 36 is a standard washer 44.

FIGURE 5 shows the fastener assembly prior to 20 tightening of the nut 36 and applying a load on bolt 34 as evidenced by the gap 48 between the underside of the head 46 of the bolt 34 and the upper surface of the body portion 12 of the washer 10. This gap 48 is about equal to the height of the raised portion 14 which for a 25 1.9 cm (3/4 inch) bolt is equal to about 0.94 mm (0.037 inches).

FIGURE 6 shows the fastener assembly after the nut 36 has been tightened and a tensile load has been 30 applied to bolt 34. Note that the gap 50 between the underside of the head 46 of bolt 34 and the upper surface of the body portion 12 of the washer 10 is less than the gap 48 of FIGURE. 5. The reduction between the gap 48 and gap 50 is caused by the load exerted by tightening 35 nut 36 causing protuberances 14 to deform into the body portion 12 of the washer 10. The number and size of the

protuberances 14 are such that the average gap 50 is about 0.38 mm (0.015 inches) when the proper tensile load has been applied to the bolt 34. The average gap 50 is arrived at by measuring the gap 50 adjacent each of the protuberances and determining the average of such measurements.

It has been found that a load indicating washer having the following dimensions more uniformly and consistently indicated the proper allowable load in a bolt 34 when the average gap 50 of FIGURE 6 was about 0.38 mm (0.015 inches).

- (1) Bolt 34 was 1.9 cm (3/4 inch) in diameter and known by person skilled in the art as a high-strength structural bolt A325.
- (2) Washer 10 was made from 1040 steel annealed, with a hole 20 size of about 1.98 cm (0.780 inches) to about 2.00 cm (0.790 inches), an outside diameter of about 4.15 cm (1.635 inches) to about 1.635 inches and a body portion 12 thickness of about 3.50 mm (0.138 inches) to about 3.86 mm (0.152 inches).
- (3) The protuberances 14 were five in number spaced as shown in FIGURE 1. Referring to FIGURE 3, D was equal to about 9.4 mm (0.37 inches), H was equal to about 1.14 mm (0.045 inches), J was equal to about 6.86 mm (0.270 inches), the radius for arcuate end surfaces 26 was about 6.93 mm (0.273 inches). Referring to FIGURE 1, E was equal to about 2.54 mm (0.100 inches) to about 2.82 mm (0.110 inches), F was equal to about 10.44 mm (0.411 inches) to about 10.69 mm (0.421 inches) and G was equal to about 2.49 mm (0.098 inches).

5

- (4) Use of the washer 10 as dimensioned above and not heat-treated, allowed bolt 34, described above, to be tensioned to a load of between 12,700 kg (28,000 pounds) to about 15,250 kg (33,600 pounds) and at such load the average gap 50 was consistently about 0.38 mm (0.015 inches).

10 While I have described my invention hereinabove in considerable detail, I do not wish to be limited narrowly to the exact and specific particulars disclosed, but I may also use such substitutes, modifications and equivalents as are included within the spirit of my invention or pointed out in the appended claims.

Claims:

1. A non-heat treated load indicating washer (10) for
visually indicating the magnitude of a compressive force
5 applied by a fastener (34, 36, 46) to opposed faces
thereof having a body portion (12), a plurality of
protuberances (14) struck from said body portion at
spaced intervals and integrally formed with the material
of said body portion, said protuberances being spaced
10 from the inner (16) and outer (18) peripheries of said
body portion, each protuberance being oblong in outline
and defined by substantially parallel side surfaces (22),
the improvement comprising each of said protuberances
(14) having a truncated concave basal surface (24) lying
15 within the confines of said body portion (12) and a
convex surface (32) which extends out of the plane of
said body portion, the number and size of said protuber-
ances (14) being dimensioned with respect to said com-
pressive force so that said protuberances will deform
20 into said body portion (12) when said compressive force
reaches a predetermined magnitude.
2. A fastener assembly (34, 36, 46) including a bolt
(34) having its shank extending through members (38, 40)
25 clamped together by the fastener assembly, a non-heat
treated load indicating washer (10) positioned about said
shank and interposed between a clamping surface of said
fastener assembly and adjacent one surface of said
member, said washer having a body portion (12), a
30 plurality of protuberances (14) struck from said body
portion at spaced intervals and integrally formed with
the material of said body portion (12), said protuberan-
ces (14) being spaced from the inner (16) and outer (18)
peripheries of said body portion, each protuberance (14)
35 being oblong in outline and defined by substantially
parallel side surfaces (22), each of said protuberances

having a truncated concave basal surface (24) lying within the confines of said body portion (12) and a convex surface (32) which extends out of the plane of said body portion, the number and size of said protuberances (14) being dimensioned with respect to said compressive force so that said protuberances will deform into said body portion (12) when said compressive force reaches a predetermined magnitude.

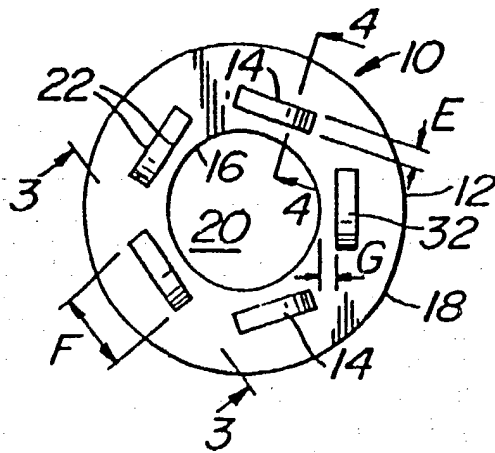


FIG. 1

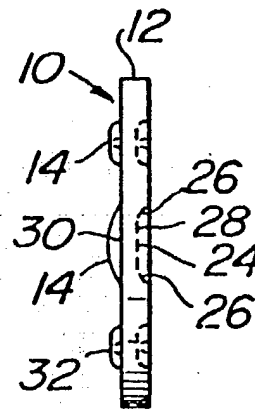


FIG. 2

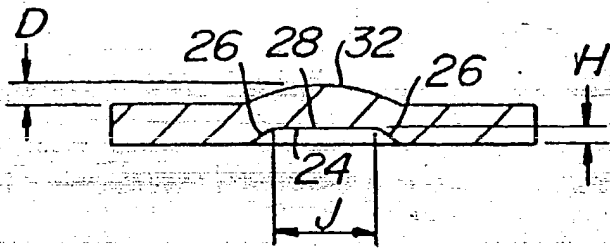


FIG. 3

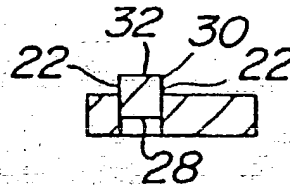


FIG. 4

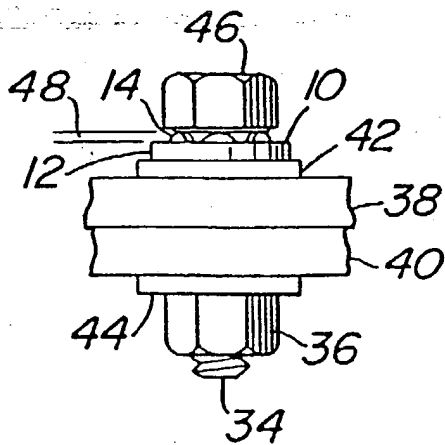


FIG. 5

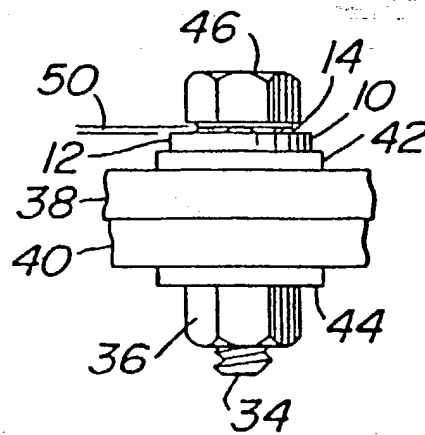


FIG. 6



DOCUMENTS CONSIDERED TO BE RELEVANT			EP 83107631.0
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 7)
D,X	<u>US - A - 3 187 621 (RODNEY FRANCIS TURNER)</u> * Claims 1,2; fig. 1-7 * --	1,2	F 16 B 31/02 F 16 B 43/00
X	<u>GB - A - 1 506 674 (COOPER & TURNER LIMITED)</u> * Claims 1-17; fig. 1-8 * --	1,2	
X	<u>GB - A - 1 143 398 (COOPER & TURNER LIMITED)</u> * Claims 1-8; fig. 1-4 * --	1,2	
A	<u>GB - A - 1 263 385 (STANDARD PRESSED STEEL CO.)</u> * Claim 1; fig. 1-9 * --	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl. 7)
A	<u>US - A - 3 948 141 (KATSUMI SHINJO)</u> * Claim 1; fig. 1-11 * --	1,2	F 16 B
A	<u>US - A - 4 103 725 (MICHIO ABE)</u> * Columns 1,2; fig. 1-8 * ----	1,2	
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 10-10-1983	Examiner REIF
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

